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COMMONWEALTH OF AUSTRALIA

Council for Scientific and Industrial Research

BULLETIN No. 222

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PACIFIC OCEANIC FISHERY
INVESTIGATIONS

The Chaetognatha of South-eastern Australia

(Division of Fisheries—Report No. 14)

By

J. M. THOMSON, M.Sc.

MELBOURNE, 1947

Registered at the General Post Office, Melbourne, for transmission by post as a periodical.

C.12481/46 J. J. GOURLEY, Government Printer, Melbourne.

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SUMMARY

The identity of the species of Chaetognatha present in the plankton of south-eastern Australian waters is discussed. A classification of maturity stages in Chaetognaths is suggested. Degrees of protandry can be differentiated.

Grouping of the epiplanktonic species into tropical, temperate, and cold-water forms is possible. Deep-water species are not so divisible. Tropical, temperate, and cold-water forms are distinguishable. Tropical species do not extend into Bass Strait. Only one tropical species shows a significant difference in the frequency of occurrence in neritic and oceanic waters. All but two of the non-tropical forms show significantly more frequent occurrence in the oceanic zone.

The possibility of using Chaetognatha as indicator organisms seems restricted to examining the degree of penetration by cold and warm water masses, northwards and southwards respectively, in the region between Bass Strait and Jervis Bay; and, possibly, to showing influxion of oceanic waters into the neritic zone.

The Chaetognatha of South-Eastern Australia*

I. OBJECTS OF INQUIRY

The aim of fisheries research is the rational exploitation of the sea. The estimation of the productivity of the sea is all-important. The productivity is dependent to a marked degree on the hydrological conditions and an index to these is given by the amount and nature of the plankton present. The study of plankton organisms is concerned particularly with the fluctuations in amount and type of the different forms available, for the ultimate food supply of oceanic life is the plankton. Secondly, the plankton is being studied more and more for the possibility of using particular forms as an index to hydrological conditions. In the opening up of more or less undeveloped areas, studies of the zoogeographical affinities of the local fauna may indicate the lines upon which the fisheries will develop.

Chaetognatha have been used to a considerable extent in the second and third of these studies. In this study the species present in the Eastern Australian plankton are identified and an indication is given of the general distribution and behaviour of the animals. The areas where use of Chaetognatha as indicators seems probable are defined. When analysis and interpretation of the hydrological data are complete a more precise statement on the indicator value of the various species may be made.

II. METHODS OF INVESTIGATION

1. Material

The source of material for this inquiry is the collection of plankton hauls made by the C.S.I.R. Research vessel *Warreen* during the period May, 1938–January, 1941. The stations extended from the Southern Queensland coast to South Australia and Tasmania, a coastal strip extending from 24°S. to 45°S. and from 135°E. to 154°E. Although the area was traversed several times, the demands of more specific fishery problems made it impossible for stations representative of each region to be repeated, nor was it possible to take hauls at specific intervals. This fact, together with the high error implicit in the method of collection, makes it impossible to interpret quantitative data in any but gross or indicative forms.

Vertical, horizontal, and oblique hauls at various depths were made by the *Warreen* by N70, N100, and N200 nets.

Thompson (1942) has discussed the reliability of these hauls. An additional complication in the case of Chaetognatha is that all species are not fished as efficiently by all nets, as is shown particularly by the simultaneous horizontal hauls. The size and activity

* Typescript received July 5, 1946.

of different species varies considerably, some species being mature at 7 mm. whereas others are not adult until over 50 mm. and all gradations exist between. The activity of the larger species enables them to avoid to a considerable extent the smaller N70, while the small size of some of the species permits them to escape through the mesh of the larger nets. The larger nets therefore are more reliable for the capture of the large species and the small net for the small species.

2. Technique in Identification

(i) *Examination*

Specific differentiation in the Chaetognatha is based upon varying combinations of characters, which differ in the ease with which they may be distinguished. However, in well-preserved mature specimens the shape and position of the seminal vesicle is diagnostic. But immature or damaged specimens can only be determined by the combination of a number of features.

For most purposes examination of unstained specimens either as temporary mounts or submerged on a watch-glass is preferable. Staining is unnecessary for the external features used in identification (except the corona ciliata). Indeed staining obscures much that is useful in the head region owing to the uneven degree to which various tissues take up stains. Observations made upon permanent mounts may be misleading, since the curvature of the head will inevitably hide some features of the head armature, and the delicate fins are usually damaged in the process.

To ascertain the correct head armature formula it is necessary to examine both ventral and dorsal surfaces of the head. As a rule the anterior teeth are more easily inspected from the ventral surface, and the posterior teeth from the dorsal. But the posterior teeth curve laterally around the head and any contraction will cause some teeth to be out of sight from above. Sometimes the hood tends to hide the posterior teeth. This is particularly so with the smaller species and lateral inspection is necessary.

The seizing-jaws, or hooks as they may be called more briefly, require examination from the dorsal surface, otherwise the innermost (youngest) one or two, which are often extremely short, may be overlooked.

(ii) *Staining*

The only external feature that requires staining is the corona ciliata, which however is useful only as a confirmatory characteristic, especially as it is frequently damaged in capture. Fowler's (1905) method of immersing the animal in a weak solution (c. 1 per cent.) of methylene blue for about one minute is both simple and productive of good results. In heavily stained specimens the corona is inevitably obscured.

Staining is necessary to make out the gonads of the more opaque species. In the transparent species and in those which are only moderately opaque, ovaries and testes and spermatocytes and spermatozoa can be made out easily without staining. In those species with less thick muscle walls, immersion in 5 per cent. methylene blue

for five minutes will bring the gonads into sharp relief. But in the most strongly-muscled species borax-carmine followed by methyl blue gives better results. Alum-carmine and haemalum give good results in some cases but are unreliable. The methylene-blue stain is preferable because the colour soon fades and leaves the specimen unaffected. On storing the other stains react on the specimens so as to obscure the internal structure. Similar obscuring was noted in some specimens in the collection of the Western Australian Museum which were stained by Ritter-Zahony (1910*a*) in identifying the Hamburg Museum Expedition's small sample of Chaetognaths from Sharks Bay.

3. Maturity Stages

Reference to the maturity stages of Chaetognatha has been made but seldom and then usually in inexact general terms. The work of two men, however, has laid the basis for a more precise classification of maturity stages. Kramp (1917) and Russell (1932*a*) proposed essentially similar divisions, using combinations of maturity stages of sperms and ova. Their divisions were suitable for the species on which their work was done. But the study of a greater number of species reveals that the protandry of Chaetognatha is not developed to the same degree in all. Kramp (1939) found this dissimilarity in a later study. For each of the species he studied he proposed systems in which the stages were not necessarily equivalent to those of other species. As a result comparison of growth stages is difficult.

Equivalent stages for all species can be devised by considering only one pair of gonads, namely, the ovaries. These start developing at the same time as the testes but mature later. The stages which may be adopted are then:—

Juv.: juvenile in which the primitive germ cells of the gonads have not commenced to develop.

St I: the gonads are being formed.

St II: ova are present, small and all alike.

St III: some ova are large, ripening has begun.

St IV: all the ova are large.

In general the spermatocytes first appear in stage II, though sometimes a few occur in stage I. Spermatocytes and spermatozoa pack the tail cavity during late stage II and stage III. In some species they are extruded before the end of stage III, but in others they are still present in stage IV.

The Chaetognatha are then divisible into three groups on the degree of protandry. One group comprises species in which protandry is marked, and another those in which it is slight. For practical purposes they may be distinguished on the criterion of whether the sperm have or have not been evacuated by the time stage IV is reached. The third group contains only *Sagitta enflata* which is thought to have two cycles of reproduction (see below) otherwise it would fall in the markedly protandric group.

The Australian species are grouped as follows:

Markedly Protandric.	Slightly Protandric.	Cyclic Protandry.
Sagitta lyra	*S. bipunctata*	*S. enflata*
S. hexaptera	*S. neglecta*	
S. pulchra	*S. robusta*	
S. planctonis	*S. ferox*	
S. minima	*S. bedoti*	
S. decipiens	*S. regularis*	
S. serratodentata (*tasmanica* type)	*S. serratodentata* (*atlantica* and *pacifica* types)	
Eukrohnia hamata	*Krohnitta pacifica*	
Pterosagitta draco	*K. subtilis*	

S. serratodentata is somewhat variable, its sub-species (see under Systematic Notes) differing in type. From Kramp's work it is evident that the northern hemisphere *S. elegans* and *S. maxima* fall into the markedly protandric group. *S. setosa,* another northern form studied by Russell (1932*b*) falls in the same group. In general, the markedly protandric forms are those species attaining a greater size, and the other group contains the smaller forms.

Stage V of Kramp (1939) in which the ovary has been evacuated has not been observed. Kramp himself has only seen it in *E. hamata* and he states that it is hypothetical as far as other species are concerned.

It should be noted also that the size of ripe ova varies from one species to another. In *S. serratodentata* and *S. lyra* they are particularly small. In *K. pacifica* they become extraordinarily large. The ova of other species range in between.

4. Recordings

Several authors, and in particular Fowler (1905), have stressed the desirability of recording the formula for the head armature. Accordingly counts were made of samples from every haul studied and the result was recorded in composite tables of the type used by Ritter-Zahony (1911*c*). The measurements of length of the body, and comparative length of the tail segment have been made excluding the tail fin, as recommended by Ritter-Zahony (1911*c*), Jameson (1914), and others. Measurements such as those made by Fowler (1905, 1906) and by Burfield and Harvey (1926) which include the tail fin in both measurements may frequently be misleading as the delicate tail fin inevitably suffers damage.

The class-intervals adopted are 5 mm. for those species attaining a length greater than 25 mm., and 2 mm. for those maturing at a lesser length. The maturity distribution of the specimens falling in each class-interval is also given in the tables. All recordings given are from *Warreen* material.

III. PREVIOUS RECORDS FROM SOUTH-EASTERN AUSTRALIA

Whitelegge (1889) and Waite (1899) record the presence of Sagittids in the plankton of New South Wales coastal waters. Ritter-Zahony (1909*a*, 1911*a*) made a few casual identifications from Great Sandy Island, Queensland. Johnston (1909) described a new species, *Sagitta australis*, from Maroubra Bay, New South Wales. The validity of this species is discussed below. Johnston and Taylor (1919) identified a number of species from the coastal waters of New South Wales and southern Queensland. Johnston and Taylor (1921) reporting on the Chaetognatha taken by the Australian Antarctic Expedition included one record from the coast of Tasmania. Tokioka (1940*a*) worked on a small collection from the New South Wales coast. Between them Johnston and Taylor, Ritter-Zahony, and Tokioka have recorded sixteen species from this part of the Australian coast. However, it should be noted that three of these species are of questionable validity (*Sagitta australis* Johnston and *S. tenuis* Conant identified by Johnston and Taylor, and *S. ai* Tokioka).

IV. SYSTEMATIC NOTES ON THE *WARREEN* CHAETOGNATHA

The classification adopted is that published by Ritter-Zahony in his two revisions of the group (1911*a*, 1911*c*). Where well-preserved mature specimens were examined full use was made of the shape and position of the seminal vesicle as recommended by Tokioka (1939*c*).

Only the synonymy subsequent to 1910 is included below except for certain references which were overlooked by or unknown to Ritter-Zahony (1911*a*, 1911*c*). In some respects also the work of Ritter-Zahony has been corrected in the light of later investigations.

Species List

Genus SAGITTA Quoy and Gaimard (1827).
- *S. hexaptera* d'Orbigny (1843).
- *S. lyra* Krohn (1853).
- *S. enflata* Grassi (1881).
- *S. bipunctata* Quoy and Gaimard (1827).
- *S. robusta* Doncaster (1902).
- *S. ferox* Doncaster (1902).
- *S. serratodentata* Krohn (1853).
- **S. bedoti* Beraneck (1895).
- *S. neglecta* Aida (1897).
- *S. regularia* Aida (1897).
- *S. minima* Aida (1897).
- *S. pulchra* Doncaster (1902).
- *S. planctonis* Steinhaus (1896).
- **S. decipiens* Fowler (1905).

Genus SPADELLA Langerhans (1880).
- *Sp. cephaloptera* (Busch) (1851).

Genus PTEROSAGITTA Ritter-Zahony (1911*a*).
- *Pt. draco* (Krohn) (1853).

* Recorded for the first time from South-eastern Australian waters.

Genus KROHNITTA Ritter-Zahony (1911*a*).
K. subtilis (Grassi) (1881).
**K. pacifica* (Aida) (1897).
Genus EUKROHNIA Ritter-Zahony (1909*b*).
**E. hamata* (Möbius) (1895).

Sagitta hexaptera d'Orbigny (1853).

Synonymy—

S. hexaptera Darwin (1844); Aida (1897); Moltschanoff (1907); Michael (1909, 1911, 1913*b*, 1919); Ostenfeld (1909); Shipley (1910); Ritter-Zahony (1911*a*, 1911*b*, 1911*c*); Germain (1913); Jameson (1914); Germain and Joubin (1916); Pratt (1916); Oye (1918); Huntsman (1919); Johnston and Taylor (1921); Gray (1923); Bigelow (1926); Burfield and Harvey (1926); Burfield (1930); Bollman (1934); Fraser (1937); Kuhl (1938); Tokioka (1939*c*, 1940*a*, 1940*b*).
S. bipunctata Eydoux and Souleyet (partim) (1844).
S. magna Strodtmann (1892); Doncaster (1902); Michael (1909).
S. tricuspidata Strodtmann (1892); Doncaster (1902).
S. darwini Grassi (1883).
S. fowleri Benham (1912).

Formula—

Length.*	Tail.*	Hooks.	Anterior Teeth.	Posterior Teeth.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%
50–55	15–18	4–8	2–4	0–3	66	34	..	..
45–50	17–19	6–8	3	0–3	25	75	..	..
40–45	16–19	6–8	2–3	1–4	..	100	..	..
35–40	18–21	8–10	2–4	2–3	..	80	20	..
30–35	17–21	8–10	2–4	1–3	..	50	50	..
25–30	18–22	8–10	2–4	1–3	..	50	50	..
20–25	16–23	6–10	1–4	1–3	..	37	63	..
15–20	22–23	9–10	2–3	2–5	..	8	59	33
10–15	20–25	8–11	2–3	2–3	..	..	..	100
5–10	22–25	9–11	2–3	1–5	..	..	..	100

* Size-intervals should be taken as reading 5–9·99; 10–14·99, &c. Tail length is expressed as a percentage of total length.

Although the largest specimen obtained was 55 mm. in length, only 8 mm. shorter than the longest recorded hexapteran, nevertheless no fully mature specimens were taken.

S. lyra Krohn (1853).

S. lyra Hertwig (1880); Aida (1897); Ritter-Zahony (1911*a*, 1911*c*, 1914); Michael (1911, 1913*b*, 1919); Shipley (1910); Oye (1918); Huntsman (1919); Johnston and Taylor (1921); Burfield and Harvey (1926); Bigelow (1926); Bollman (1934); Kuhl (1938); Tokioka (1939*c*, 1940*a*, 1940*b*).
S. hexaptera Strodtmann (1892) (partim).
S. furcata Krumbach (1903); Fowler (1906); Michael (1909).

S. gazellae Ritter-Zahony (1909*b*, 1911*a*, 1911*c*); Michael (1913*b*, 1919); Burfield (1930); Bollman (1934); Kuhl (1938).

Pseudosagitta grimaldi Germain and Joubin (1912).

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%
45–50	10–12	7–9	3–6	6–8	8	92	..	..
40–45	11–14	7–9	3–6	6–9	..	80	20	..
35–40	13–16	7–9	3–6	5–8	..	75	25	..
30–35	13–16	6–8	3–6	7–9	..	36	64	..
25–30	14–18	6–9	3–6	4–9	..	20	70	10
20–25	14–17	7–8	3–6	4–7	..	..	40	60
15–20	14–19	8–9	3–5	4–7	..	..	..	100
10–15	15–20	8–9	4–7	4–10	..	..	..	100
5–10	19–22	9–12	3–5	2–6	..	..	..	100
0–5	15–25	5–11	2–4	2–7	..	..	..	100

Inspection of the *Warreen* material confirms the view expressed by Johnston and Taylor (1921) and Tokioka (1939*c*) that *S. lyra* Krohn and *S. gazellae* Ritter-Zahony are the extremes of variation of one species. The *gazellae* form is typical of cooler seas and in the south-eastern Australian region occurs only in Tasmanian waters. The *lyra* form is typical of the warmer waters. However, in the area between the two typical populations there occur intermediate types, similar to those found by Tokioka in Japanese waters. This intermediate area is approximately between 37° and 40° South. Taking these intermediate forms into consideration, neither Ritter-Zahony's criteria of different combination of characters nor Michael's differentiation on the extent of the rayless inner zone of the lateral fins can be regarded as valid.

Michael referred *S. maxima* (Conant) to the synonymy of *S. lyra*. The published descriptions show them to be very similar, the only marked difference being the distinctly greater proportionate length of the tail region in *maxima*. However, Huntsman (1919) states that he had no difficulty in separating the two.

S. enflata Grassi (1881).

S. enflata Beraneck (1895); Aida (1897); Doncaster (1902, 1903); Ritter-Zahony (1909*a*, 1909*b*, 1910*a*, 1911*a*, 1911*b*, 1911*c*); Michael (1909, 1911, 1913*b*, 1919); Shipley (1910); Jameson (1914); Germain and Joubin (1916); Bigelow (1917, 1926); Oye (1918); Johnston and Taylor (1919); Huntsman (1919); Audigé (1921); Gray (1923); Burfield and Harvey (1926); Burfield (1930); Germain (1930); Cowles (1930); John (1933*a*, 1937); Bollman (1934); Kuhl (1938); Tokioka (1939*c*, 1940*a*, 1940*b*); Delsman (1939).

S. bipunctata Eydoux and Souleyet (1844) (partim).

S. gardineri Doncaster (1903); John (1933*a*); Lele and Gae (1936).

S. flaccida Doncaster (1903).
S. australis Johnston (1909); Johnston and Taylor (1919).

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.IV.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%	%
20–25	15–18	9–11	6–10	11–17	13	37	37	13	..
15–20	13–19	8–10	6–11	10–18	8	24	36	24	8
10–15	13–20	6–10	5–10	8–16	17	37	22	16	8
5–10	14–20	7–11	3–7	4–11	6	7	12	24	51
0–5	17–24	8–10	1–4	1–6	..	..	..	..	100

Ritter-Zahony (1911*a*) referred *S. australis* Johnston to *enflata*. Johnston and Taylor (1919) reaffirmed the validity of the species. However, Tokioka (1940*a*) again placed *australis* in the synonymy. The holotype and co-types, including sections, have been examined by the author. The mounted whole specimens, type, and co-types are undoubtedly *enflata*. Johnston (1909) stated "There are two pairs of fins, the anterior being carried out of their normal position in most specimens." But the position (where the fins can be made out at all) is approximately that normal to *enflata*. Johnston based his opinion on the "normal" position of the anterior fins upon serial sections in the possession of the University of Sydney. Comparison of these with sections of known Chaetognaths shows that they are not of *enflata* but almost certainly of *S. pulchra*, a species closely resembling *enflata* but differing amongst other things in that the anterior fins extend to the anterior ganglion.

Lele and Gae (1936) and John (1933*a*, 1937) have retained Doncaster's species *gardineri* on the grounds that the anterior fin is both larger and extends more anteriorly than in *enflata*. This cannot in itself amount to a specific difference. In any case the *Warreen* material has yielded *gardineri* and *enflata* types with intergrades between them.

Michael (1919) drew attention to the fact that in *S. enflata* the ovaries of large individuals were frequently barely approaching maturity, whereas in considerably smaller specimens the ovaries were quite mature. He failed to find any differences which would indicate that more than one species was concerned. The Australian specimens of *enflata* displayed a similar phenomenon. After the examination of many specimens it seems certain that Michael's suggestion that the gonads in this species may mature periodically is correct. Occasionally individuals were found in which the ovaries were fully mature, but the testis was apparently just starting to develop. In some, remnants of a ruptured vesicle were apparent. It is possible, however, that specimens concerned were displaying an arrested development of the testis (or part of it). Another explanation of the size difference is a variability in brood lengths. The sampling method was not such, however, as to give any evidence on this point. Both large and small types may occur in the one swarm.

S. bipunctata Quoy and Gaimard (1827).

S. bipunctata Gunther (1903); Fowler (1905); Ostenfeld (1909, 1916); Ritter-Zahony (1911*a*, 1911*c*); Michael (1909,

1913*b*); Shipley (1910); Germain (1913); Jameson (1914); Oye (1918); Huntsman (1919); Johnston and Taylor (1919); Burfield and Harvey (1926); Burfield (1930); Menon (1931); Winogradow (1933); Bollman (1934); Kuhl (1938); Tokioka (1939*c*, 1940*a*, 1940*b*).

? *S. setosa* Keferstein (1862).

? *S. germanica* Uljanin (1870).

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.IV.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%	%
16–18	22–24	8–10	6–7	11–13	64	36	..	..	..
14–16	24–25	8–10	5–7	8–16	50	25	25	..	..
12–14	23–25	8–9	5–8	10–16	15	70	15	..	..
10–12	22–26	8–9	5–7	11–15	10	40	35	15	..
8–10	25–26	9–10	6–7	10–11	..	33	33	34	..
6–8	25–26	7–8	2–6	3–11	..	..	..	64	36
4–6	26–27	6–9	2–5	3–8	..	..	..	..	100
2–4	27–29	6–7	1–2	1–2	..	..	..	..	100

As Tokioka (1939*c*) has pointed out there is a well marked swelling of the epidermis (collarette?) immediately in front of the seminal vesicle in *bipunctata*. This feature has not been mentioned in descriptions of the species from Atlantic waters.

S. bipunctata has frequently been recorded from European seas. Meek (1928) and Russell (1932*a*) have shown that this oceanic form rarely occurs there, but that *S. elegans* and *S. setosa* have been mistakenly identified as such. The *bipunctata* of Hodgson (1895), Marshall (1925), M'Intosh (1936), and Burfield (1927) are almost certainly *elegans*. Russell (1925, 1928) in his early work confused *elegans* and *setosa* under the one name *bipunctata*.

S. robusta Doncaster (1902).

S. robusta Ritter-Zahony (partim) (1909*a*, 1909*b*, 1910*a*, 1910*c*, 1911*a*, 1911*c*); Jameson (1914); Oye (1918); Johnston and Taylor (1919); Gray (1923); Burfield and Harvey (partim) (1926); Burfield (partim) (1930); John (1933*a*, 1937); Kuhl (1938).

S. ferox Fowler (1906); Michael (1909, 1913*b*, 1919),

S. ai Tokioka (1939*c*, 1940*a*, 1940*b*).

S. planctonis Delsman (1939).

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.IV.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%	%
20–22	25–30	5–6	4–6	9–10	100	..	..	..	..
18–20	26–29	5–6	4–7	11–14	20	80	..	..	..
16–18	27–29	5–7	4–7	12–13	..	100	..	..	..
14–16	26–28	6–7	6–7	11–14	..	64	36	..	..
12–14	25–27	6–8	6–9	10–13	..	25	45	30	..
10–12	27–29	6–8	4–7	9–11	..	..	40	60	..
8–10	27–31	6–8	6–8	9–11	..	..	..	100	..
6–8	27–32	5–9	3–6	7–14	..	..	..	..	100

The identity of *S. robusta* is most confused. The original description by Doncaster is inadequate for certain identification. Doncaster also described another species under the name of *S. ferox* which he said was hardly distinguishable from *robusta* and should perhaps be included in that species. Fowler (1906) described *S. ferox* from the East Indies. He did not find *robusta* there though he identified a species as such from elsewhere. Ritter-Zahony (1909*a*, 1911*a*) placed *ferox* as a synonym of *robusta*. Michael (1911, 1919) retained *S. ferox* as a separate species on Fowler's description. He failed to find *robusta* in the Philippine material.

Tokioka (1939*c*) described a new species, *S. ai*, which is identical with Michael's description of *ferox* and with the less complete one by Fowler. Tokioka lists several features to distinguish *ai* from the closely allied *robusta*. The distinction in armature formula is not as distinct as Tokioka thought. The two are easily differentiated in the *Warreen* material and there is an almost complete overlap in the formulae. There is however a tendency for the *ai* form to have fewer hooks than the *robusta*. The other principal difference between the two is the fact that *ai* matures at from 16-20 mm., while *robusta* matures at 10-13 mm. A similar difference held for Fowler's *ferox* and *robusta*. But in Doncaster's original description *robusta* was given as reaching 16 mm. and *ferox* only about 13 mm.

The solution lies partly in the work of Burfield and Harvey (1926). These authors obtained a large amount of material from the Indian Ocean and also re-examined Doncaster's original specimens. They found that Doncaster's types for *robusta* reached over 16 mm. Their revised head armature formula is more typical of Tokioka's *ai* and Fowler's *ferox* than of their *robusta*. But Burfield and Harvey merged *ferox* in *robusta* on the grounds of the similarity of head armature. But identity of head armature alone is not sufficient reason to place them together, and it seems certain that the small *ferox* of Doncaster is also the small *robusta* of Tokioka and Fowler. Ritter-Zahony undoubtedly placed the two together. He records (1909*b*) that a few larger individuals had seminal vesicles without heads which condition is typical of *robusta* (*ai*) whereas the more numerous smaller individuals had a head to the seminal vesicle which is typical of *ferox*. The confusion seems to have arisen over the similarity of head armature coupled with the inadequate original description.

Besides the differences in the seminal vesicle there are certain constant differences in proportion. The head in particular is broader in *robusta* than in *ferox*.

—	Width.	Width of Head.	Length of Anterior Fin.	Length of Posterior Fin.
S. robusta	6·1–6·6	9·4–11·4	25·5–30·4	25·4–30·8
S. ferox	5·4–5·8	7·7–8·3	21·1–22·7	25·0–27·8

All figures expressed as percentage of total length.

Some of the specimens were the largest yet recorded for the species. One attained 22 mm. in length and several of about 20 mm. were taken. A hitherto unrecorded phenomenon is the fact that as the

animal approaches full maturity (19-22 mm.) there is an extraordinary proliferation of the collarette in the region between the anterior fin and the head.

Delsman (1939) has drawn as *planctonis* a typical late stage III *robusta*. As Oye (1918) found *robusta* numerous in this region and neither he nor Fowler (1906) found *planctonis*, Delsman's species seems sure to be *robusta*.

S. ferox Doncaster (1902).

S. japonica Galzow (1909).

S. robusta Ritter-Zahony (partim) (1909*a*, 1909*b*, 1910*a*, 1910*c*, 1911*c*); Burfield and Harvey (partim) (1926); Tokioka (1939*c*, 1940*a*, 1940*b*).

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.IV.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%	%
12–13	25–27	6–8	6–7	10–13	80	20	..	..	..
10–12	26–28	6–8	5–7	9–13	10	60	30	..	..
8–10	27–29	7–8	6–7	11–14	..	..	100	..	..
6–8	27–29	7–9	6–7	9–14	..	..	..	50	50
4–6	28–30	7–9	4–5	6–9	..	..	..	10	90

The synonymy of this species has already been discussed above under *S. robusta*.

S. serratodentata Krohn (1853).

S. serratodentata Strodtmann (1892); Beraneck (1895); Aida (1897); Doncaster (1903); Fowler (1906); Ritter-Zahony (1908, 1909*b*, 1910*a*, 1911*a*, 1911*b*, 1911*c*); Michael (1909, 1911, 1913*b*, 1919); Shipley (1910); Jameson (1914); Bigelow (1915, 1922, 1926); Huntsman (1919); Johnston and Taylor (1919, 1921); Gray (1923); Burfield and Harvey (1926); Burfield (1930); Russell (1932*a*, 1935*a*, 1935*b*, 1936*b*, 1939); Kuhl (1938); Tokioka (1939*c*, 1940*a*, 1940*b*).

S. gegenbauri Fol (1879).

? *S. pseudoserratodentata* Tokioka (1939*c*).

This species can be divided into three subspecies whose armature formulae differ somewhat. Two of these Tokioka has already distinguished as the *pacifica* and *atlantica* forms.

S. s. pacifica Tokioka.

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.IV.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%	..
14–16	22–24	5–6	9–10	19–22	100	..	..	..	..
12–14	22–26	5–6	9–12	19–23	60	20	20	..	..
10–12	22–26	5–7	7–10	17–22	10	35	50	5	..
8–10	22–26	6–8	7–10	15–25	..	8	46	46	..
6–8	22–26	6–8	7–9	10–17	..	..	5	40	55
4–6	25–28	6–8	3–8	4–8	..	..	..	14	86
2–4	26–28	6–8	1–3	2–4	..	..	..	..	100

S. s. atlantica Tokioka (1939*c*).

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.IV.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%	%
12–14	24–26	5–7	7–10	11–14	50	50	..	..	..
10–12	24–27	5–8	7–9	11–14	20	40	40	..	..
8–10	24–27	7–8	5–8	8–14	..	10	50	40	..
6–8	25–31	6–9	4–7	8–14	..	..	5	15	80
4–6	25–30	6–8	3–6	4–6	..	..	..	4	96
2–4	27–31	6–8	1–3	2–4	..	..	..	..	100

S. s. tasmanica n. subsp.

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.IV.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%	%
18–20	22–24	7	7–9	15–19	100	..	..	..	..
16–18	22–26	6–7	7–9	15–17	60	40	..	..	..
14–16	22–26	6–8	7–9	13–16	10	70	20	..	..
12–14	23–27	6–8	6–8	11–16	..	49	51	..	..
10–12	23–27	6–8	6–8	10–12	..	..	50	37	13
8–10	23–27	6–9	4–7	6–12	..	..	5	58	37
6–8	24–28	6–8	2–4	5–8	..	..	..	10	90
4–6	26–28	6–8	1–2	3–5	..	..	..	..	100

The formulae overlap considerably but certain differences are apparent; *tasmanica* attains a much greater length than the other subspecies; it tends to have more hooks but fewer teeth than *pacifica*; its formula overlaps to a much greater degree with *atlantica*; *atlantica* has fewer hind teeth than *pacifica* (except in the young stages).

There are other differences in structure which may be recorded in tabular form. In particular the variation in the form of the mature seminal vesicle should be noted.

——	*pacifica.*	*atlantica.*	*tasmanica.*
Mature length ..	11–16 mm.	10–14 mm.	15–20 mm.
Body width ..	4·6–4·9 per cent. total length	4–4·6 per cent.	5·9–6·3 per cent.
Body type ..	Fairly transparent, opaque when mature	As for *pacifica*	Always opaque
Teeth in mature animals	Anterior 9–12 Posterior 17–23	7–10 11–14	7–9 13–19
Seminal vesicle (see Fig. 1)	4–10 chitinous "teeth" antero-laterally	2 papillae at antero-lateral corner	Pyriform, slight head; epidermal proliferation in front and behind vesicle
Geographic distribution	35° S. northwards, sometimes extending south to 37° S.	34° S. to 39° S., occasionally to 26° S. and to 40° S.	39° S. southwards, sometimes up to 35° S.
Temperature range	14·5°–24°	12°–21°	11°–17°

The forms thus show some of the attributes of geographic subspecies, but as Tokioka has found the *atlantica* form in Japanese waters, further search may reveal that the form extends through the tropics. Or there remains the possibility that this is a case of a true ecologic sub-speciation probably correlated with temperature.

Michael (1919) and Huntsman (1919) mentioned that the *serratodentata* from cold waters showed points of difference from the warm water form. Michael's cold water form from the Californian current seems to correspond with the *tasmanica* type. But Huntsman's from east Canadian waters differs in that there are more hooks and the form is stated to be "more slender" than the warm water type.

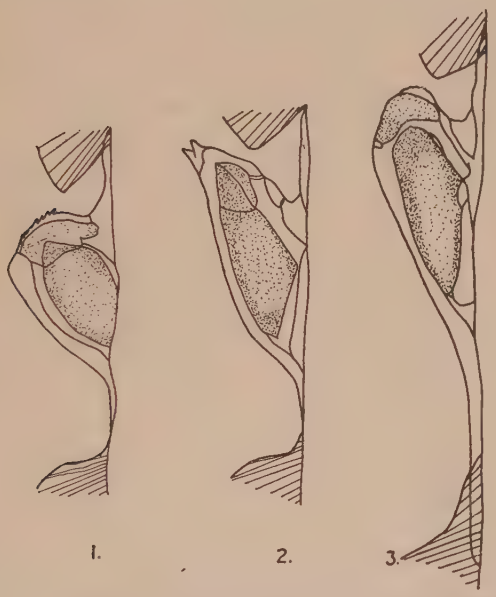

FIG. 1.—Seminal vesicles of *Sagitta serratodentata* subspecies.

1. *S.s. pacifica;* 2. *S.s. atlantica;* 3. *S.s. tasmanica.*

S. pseudoserratodentata Tokioka may be the *atlantica* form. The protruberance on the seminal vesicle may well be one of the antero-lateral papillae. On the other hand this species is recorded as being smaller and to have the corona ciliata in a different position.

S. neglecta Aida (1897).

S. neglecta Michael (1909, 1911, 1919); Ritter-Zahony (1911*a*, 1911c); Germain and Joubin (1916); Oye (1918); Johnston and Taylor (1919); Gray (1923); Burfield and Harvey (1926); John (1933*a*, 1937); Kuhl (1938); Tokioka (1939*c*, 1940*b*).

S. hispida Doncaster (1902).

? *S. bipunctata* Beraneck (1895).

S. trichodermis Oye (1918).

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.IV.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%	%
8–10	27–32	6–8	5–7	9–16	35	60	5	..	..
6–8	27–32	6–8	3–7	7–16	..	23	58	16	3
4–6	27–35	6–8	1–6	2–13	..	..	27	62	11
2–4	27–36	6–12	1–3	2–6	..	..	..	..	100

Ritter-Zahony (1911*a*) referred *S. hispida* Doncaster to *S. robusta* (*ferox*), thinking it was equivalent to *hispida* Aida. But re-examination of Doncaster's material by Burfield and Harvey (1926) showed that it was actually *neglecta*.

Tokioka (1939*c*) questioningly placed *S. bipunctata* Beraneck in the synonymy of *neglecta* but made no comment on it. Unfortunately Beraneck's work is not available in Australia.

S. trichodermis Oye is undoubtedly *neglecta*. There are no distinguishable differences. Oye mistook the outline of the pharynx for the corona ciliata and made his differentiation on that ground.

S. bedoti Beraneck (1895).

S. bedoti Ritter-Zahony (1910*a*, 1911*a*, 1911*c*); Michael (1911, 1913*b*, 1919); Oye (1918); Johnston and Taylor (1919); Burfield and Harvey (1926); Burfield (1930); Lele and Gae (1936); Kuhl (1938); Tokioka (1939*c*, 1940*b*); Subramaniam (1940).

S. bipunctata Aida (1897) (part); Yamada (1933) (part).

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.IV.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%	%
12–14	22–25	5–7	9–13	22–30	20	60	20	..	..
10–12	20–25	6–8	7–15	20–33	14	29	34	18	5
8–10	22–26	6–8	7–12	17–24	..	..	20	40	40
6–8	22–26	6–8	7–14	12–27	..	..	..	40	60
4–6	23–31	6–8	3–8	4–17	..	..	..	..	100
2–4	28–32	6–10	1–3	4–5	..	..	..	..	100

Tokioka (1940*b*) records specimens of great size (25-29 mm.) from the deeper waters of the Yellow Sea. As the species has never been recorded of a length greater than 20 mm. and rarely over 17 mm. it seems doubtful whether this identification is correct. On the other hand the formula as given by Tokioka would fall within that of *bedoti*.

S. regularis Aida (1897).

S. regularis Ritter-Zahony (1909*a*, 1910*a*, 1911*c*); Michael (1909, 1911, 1913*b*); Oye (1918); Gray (1923); Burfield and Harvey (1926); Kuhl (1938); Tokioka (1939*c*, 1940*b*).

S. pseudoregularis Oye (1918).

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.IV.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%	%
6–7	29–34	7–9	2–4	2–6	15	60	20	5	..
5–6	30–33	7–9	2–4	2–4	..	..	60	40	..
4–5	28–33	6–10	1–3	2–4	..	..	25	50	25
3–4	27–34	6–11	0–3	0–6	..	..	..	9	91
2–3	29–33	6–9	0	0	..	..	..	..	100

The *Warreen* collection contains individuals with the peculiarly elongate anterior teeth which seem to have influenced Oye to make a new species, *pseudoregularis*. He found that his specimens matured at a size smaller than usual for *regularis* but otherwise the description is identical.

S. minima Grassi (1881).

S. minima Michael (1909, 1919); Ritter-Zahony (1910*a*, 1911*a*, 1911*c*); Shipley (1910); Oye (1918); Johnston and Taylor (1919); Gray (1923); Bollman (1934); Kuhl (1938); Tokioka (1939*c*, 1940*b*).

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.IV.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%	%
8–9	16–18	7–8	3–4	9–10	60	40	..	..	..
7–8	17–23	7–10	3–5	7–10	14	86	..	..	..
6–7	17–26	7–9	2–5	4–11	..	40	30	20	10
5–6	18–24	6–10	2–4	3–9	..	21	21	37	21
4–5	20–24	7–11	1–3	2–5	..	..	5	5	90
3–4	22–26	7–10	1–4	1–4	..	..	..	2	98
2–3	22–27	8	0	0	..	..	..	..	100

The number of hind teeth is rather low, but Johnston and Taylor (1919) and Tokioka (1940*a*) have already noted a similar tendency in several Australian species.

S. pulchra Doncaster (1902).

S. pulchra Michael (1909, 1913*b*, 1919); Ritter-Zahony (1910*a*, 1911*a*, 1911*c*); Oye (1918); Johnston and Taylor (1919); Gray (1923); Burfield and Harvey (1926); Kuhl (1938); Tokioka (1939*c*, 1940*b*); Delsman (1939).

S. weberi Oye (1918).

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%
20–22	16–20	5–6	7–9	12–15	100	..	..	..
15–20	16–22	5–7	6–9	11–14	10	80	10	..
10–15	18–23	6–7	6–7	10–12	..	24	76	..
5–10	18–24	6–7	6–7	9–10	..	..	..	100

The description by Oye of *weberi* is identical with that of *pulchra* except that *pulchra* is stated to be without gut diverticuli. But Ritter-Zahony (1911*c*) has stated that this feature is not constant, but depends on the state of contraction at death.

S. decipiens Fowler (1905).

S. decipiens Fowler (1906); Ritter-Zahony (1909*a*, 1911*a*, 1911*b*, 1911*c*); Michael (1909, 1911, 1913*b*, 1919); Burfield and Harvey (1926); Bollman (1934); Kuhl (1938); Tokioka (1939*c*, 1940*b*).

S. philippini Michael (1919).

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.IV.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%	%
10–12	21–25	6–7	8–10	14–15	46	40	14	..	..
8–10	21–26	6–7	6–10	10–15	..	30	50	20	..
6–8	24–30	5–6	5–8	13–16	..	..	..	20	80
4–6	24–31	5–7	5	10–13	..	..	..	..	100

Ritter-Zahony (1911*c*) stated that the species attained 20 mm. He had himself (1911*a*) recorded specimens of up to 15 mm. from the Atlantic. However, 12 to 13 mm. seems the usual size attained in the Pacific (see Fowler 1905, 1906; Michael 1919); Mature specimens were present at 10-12 mm. in the *Warreen* material. There is a marked tendency for the number of posterior teeth to fall at the lower end of the range.

Tokioka (1939*c*) has already pointed out that the differences attributed to *philippini* by Michael in distinguishing it from *decipiens* are not significant. The differences are of the nature of individual variation and are not of specific value.

S. planctonis Steinhaus (1896).

S. planctonis Ritter-Zahony (1909*b*, 1911*a*, 1911*b*, 1911*c*, 1914); Michael (1911, 1913*b*, 1919); Germain and Joubin (1916); Kramp (1917, 1918, 1939); Johnston and Taylor (1921); Burfield and Harvey (1926); Burfield (1930); Germain (1930); Bollman (1934); John (1937); Kuhl (1938); Thiel (1938); Tokioka (1939*c*, 1940*a*).

S. zetesios Michael (1909).

S. moreauensis Gray (1923).

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%
30–35	18–21	7–9	5–7	7–13	60	40	..	..
25–30	18–22	7–9	5–7	9–12	..	50	50	..
20–25	19–22	7–9	5–6	8–12	..	10	90	..
15–20	20–22	8–10	4–6	8–11	..	..	80	20
10–15	20–24	7–9	4–6	8–13	..	..	20	80
5–10	22–26	7–10	3–6	4–10	..	..	..	100

Ritter-Zahony (1909*b*) has shown that *zetesios* is indistinguishable from *planctonis*. *S. moreauensis* Gray is identical with *planctonis* except for one feature, the position of the seminal vesicle. It is extremely doubtful whether the vesicle would be developed at the figured stage of gonad maturity. In any case the immature vesicle frequently is not in its mature position. The specimen described by Gray is so obviously *planctonis* in other respects that there can be no hesitation in assigning it to that species.

The number of posterior teeth is low in specimens of *planctonis* from Australian waters. Nor do the anterior teeth number so many as Ritter-Zahony (1911*c*) records, but approach the numbers recorded for Antarctic specimens by Ritter-Zahony (1911*a*).

The smaller specimens of these species (5-20 mm.) are extremely similar to *S. robusta*. In both, the collarette tends to meet the anterior fins and the anterior fins grow forwards with age. If no seminal vesicle is present the resemblance is striking. Delsman (1939) appears to have mistaken *robusta* for *planctonis*. Closer examination reveals two easily detected differences. The number of hooks is greater in *planctonis*. And if the animal is turned so that the interior of the animal can be viewed through the lateral fields a reticulate structure is revealed which seems to be proliferations of the mesenteries in the body cavity. No similar phenomenon has been detected in other Chaetognaths but it is always present in well-preserved *planctonis*.

Spadella cephaloptera (Busch) (1851).

Sp. cephaloptera Strodtmann (1892); Aurivillius (1899); Michael (1909, 1911); Shipley (1910); Ritter-Zahony (1911*a*, 1911*c*); Germain and Joubin (1916); Marshall (1925); Germain (1930); John (1933*b*); Kuhl (1938); Yosii and Tokioka (1939); Parry (1944).

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.III.
mm.	%				%
6·76	51·2	8	2	0	100

Only one specimen of this usually benthic species. As with the specimens reported by Yosii and Tokioka (1939), no posterior teeth were present.

Pterosagitta draco (Krohn) (1853)

Pt. draco Ritter-Zahony (1911*a*, 1911*b*, 1911*c*); Germain and Joubin (1916); Pratt (1916); Oye (1918); Michael (1919); Huntsman (1919); Johnston and Taylor (1919); Burfield and Harvey (1926); Germain (1932); Bollman (1934); Kuhl (1938); Tokioka (1939*c*, 1940*a*, 1940*b*).

Spadella draco Conant (1896); Aida (1897); Doncaster (1902, 1903); Ritter-Zahony (1910*a*); Michael (1909, 1911).

Length.	Tail.	Hooks.	Anterior Teeth.	Posterior Teeth.	St.IV.	St.III.	St.II.	St.I.	Juv.
mm.	%				%	%	%	%	%
10–12	34–35	7–10	6–9	14–16	100	..	..	..	..
8–10	38–42	7–10	6–9	14–16	75	25	..	..	..
6–8	36–44	8–10	6–9	11–16	..	13	25	62	..
4–6	37–41	8–11	4–7	8–13	..	..	..	10	90
2–4	37–44	8–9	3–5	4–7	..	..	..	..	100

Krohnitta subtilis (Grassi) (1881).

Krohnitta subtilis Ritter-Zahony (1910*a*, 1910*c* (partim), 1911*a* (partim), 1911*b*, 1911*c*); Michael (1919); Jameson (1914); Germain and Joubin (1916); Oye (1918); Huntsman (1919); Johnston and Taylor (1919); Burfield and Harvey (partim) (1926); Burfield (1930); Germain (1930); Bollman (1934); Kuhl (1938); Tokioka (1939*c*, 1940*a*, 1940*b*).

Krohnia subtilis Michael (1909); Shipley (1910).

Eukrohnia subtilis Michael (1911).

Length.	Tail.	Hooks.	Teeth.	St.IV.	St.III.	St.II.	St.I.	Juv.
mm.	%			%	%	%	%	%
12–14	32–38	7–10	9–12	75	20	5	..	..
10–12	29–38	6–9	11–13	..	50	50	..	..
8–10	30–36	5–7	9–10	..	..	40	40	20
6–8	32–40	5–7	7–10	..	..	..	10	90

K. pacifica Aida was placed on the synonymy of *subtilis* by Ritter-Zahony (1911*a*, 1911*c*). However, there were quite evidently two species of *Krohnitta* present in the *Warreen* material and these without doubt correspond to the *K. subtilis* and *K. pacifica* of Tokioka (1939*c*, 1940*b*). *K. pacifica* is mature at a shorter length than *subtilis*. *K. subtilis* is one of the most slender of Chaetognaths, while *pacifica* is distinctly broader. At the same length *pacifica* tended to have more teeth and hooks than *subtilis*. Most distinctive is the relative length of the ovary in mature individuals. The ovary is very short in even fully mature *subtilis*, but is elongated, reaching beyond the anterior end of the lateral fins in *pacifica*. Of the two *pacifica* is the more opaque, *subtilis* being quite transparent.

Krohnitta pacifica (Aida) (1897).

K. pacifica Tokioka (1939*c*, 1940*b*).

Krohnia pacifica Aida (1897); Fowler (1906); Michael (1909).

Krohnitta subtilis (partim) Ritter-Zahony (1910*c*, 1911*a*, 1911*c*); Burfield and Harvey (1926).

Krohnia viridis Aida (1897).

Krohnia kerberti Oye (1918).

Length.	Tail.	Hooks.	Teeth.	St.IV.	St.III.	St.II.	St.I.	Juv.
mm.	%	..	..	%	%	%	%	%
8–9	29–31	7–9	12–15	70	20	10	..	..
7–8	30–32	8–9	11–15	10	46	44	..	..
6–7	29–36	8–9	10–14	..	..	20	60	20

The validity of this species has been referred to above.

Eukrohnia hamata (Mobius) (1875).

E. hamata Ritter-Zahony (1909*b*, 1910*b*, 1911*a*, 1911*b*, 1911*c*, 1914); Michael (1913*b*, 1919); Jameson (1914); Germain and Joubin (1916); Pratt (1916); Kramp (1917, 1918, 1938, 1939); Huntsman (1919); Johnston and Taylor (1921); Jespersen (1923); Bigelow (1926); Burfield and Harvey (1926); Russell (1927, 1939); Bollman (1934); Hardy (1936); Kuhl (1938); Thiel (1938); Tokioka (1939*c*).

Krohnia hamata Vanhöffen (1897); Michael (1909); Damas and Kofoid (1909); Shipley (1910).

E. richardi Germain and Joubin (1912, 1916); Michael (1919); Burfield and Harvey (1926).

E. fowleri Ritter-Zahony (1909*b*, 1911*a*, 1911*c*, 1914); Kramp (1917, 1918, 1939); Johnston and Taylor (1921); Bollman (1934); Kuhl (1938).

Length.	Tail.	Hooks.	Teeth.	St.III.	St.II.	St.I.	Juv.
mm.	%			%	%	%	%
14–16	22–25	8	8–12	20	80	..	..
12–14	22–26	8–9	6–9	..	60	40	..
10–12	22–24	8–9	6–9	..	10	46	44
8–10	22–24	8–11	3–8	..	..	10	90
6–8	22–24	8–11	2–6	..	..	..	100

Despite Burfield and Harvey's (1926) retention of *E. richardi* as a separate species it seems from the published descriptions that Johnston and Taylor (1921) were justified in placing it in the synonymy of *hamata*. Neither Germain and Joubin (1912) nor Burfield and Harvey listed features which were of such magnitude that they could be regarded as more than merely individual or population differences.

E. fowleri Johnston and Taylor (1921) is evidently *hamata*. Apparently the authors were unaware that the young specimens of *hamata* had saginate jaws.

All the specimens in the present collection appear to be one species, although the warmer water forms have pigment in the eyes and those from the colder waters have not. This was one of

the main features used by Ritter-Zahony (1911*a*) to distinguish his *fowleri* from *hamata*. The other two features were the shape and extent of the corona ciliata and the number of hooks. But in the present specimens the combination of characters is not constant, specimens with the number of hooks for *fowleri* having no eye pigment; and others with eye pigment having the *hamata* number of hooks. The corona ciliata appears to be considerably variable. Almost certainly typical *fowleri* are only warm water forms of *hamata*.

V. DISTRIBUTION AND FREQUENCY OF OCCURRENCE

1. North to South

The north-south distribution of the species is shown in Fig. 4, together with an indication of the frequency of occurrence of each species. Upon the basis of the frequency of occurrence in different zones, there can be distinguished tropical, temperate and cold-water groups (see Figs. 2, 3 and 5). None of the tropical forms occur south of 38°S., that is they do not penetrate into Bass Strait. The limit of southern penetration of these species is not static. But from the evidence of a number of cruises the 37°-38°S. region appears

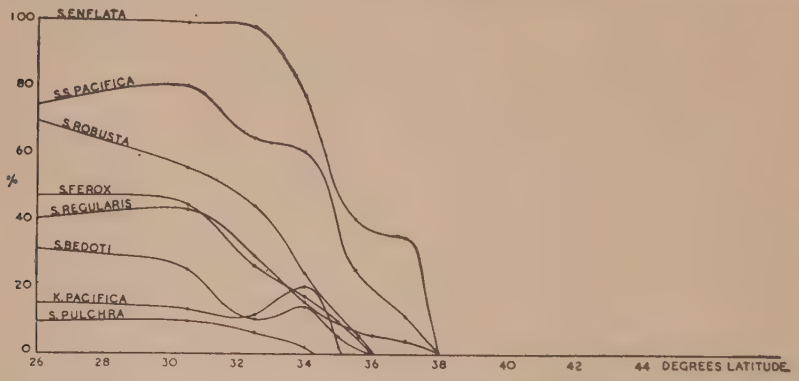

FIG. 2.—Percentage frequency distribution, north to south epiplanktonic species: tropical forms.

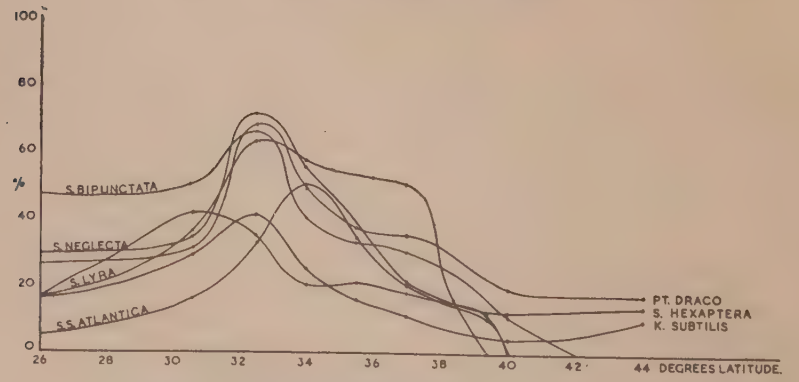

FIG. 3.—Percentage frequency distribution, north to south epiplanktonic species: temperate forms.

to be the normal limit. Fluctuations as far north as 35°S. occur. As shown in Fig. 2, the general trend of the frequency of occurrence of tropical forms is to increase towards more tropical waters.

The frequency of occurrence of the temperate forms reaches a peak between 34° and 30°S. There is a progressive decline in the frequency of occurrence both north and south of this region.

There are but two cold water forms and these are only subspecies of cosmopolitan species (Fig. 5). The distribution of these has been discussed in the systematic portion of the paper.

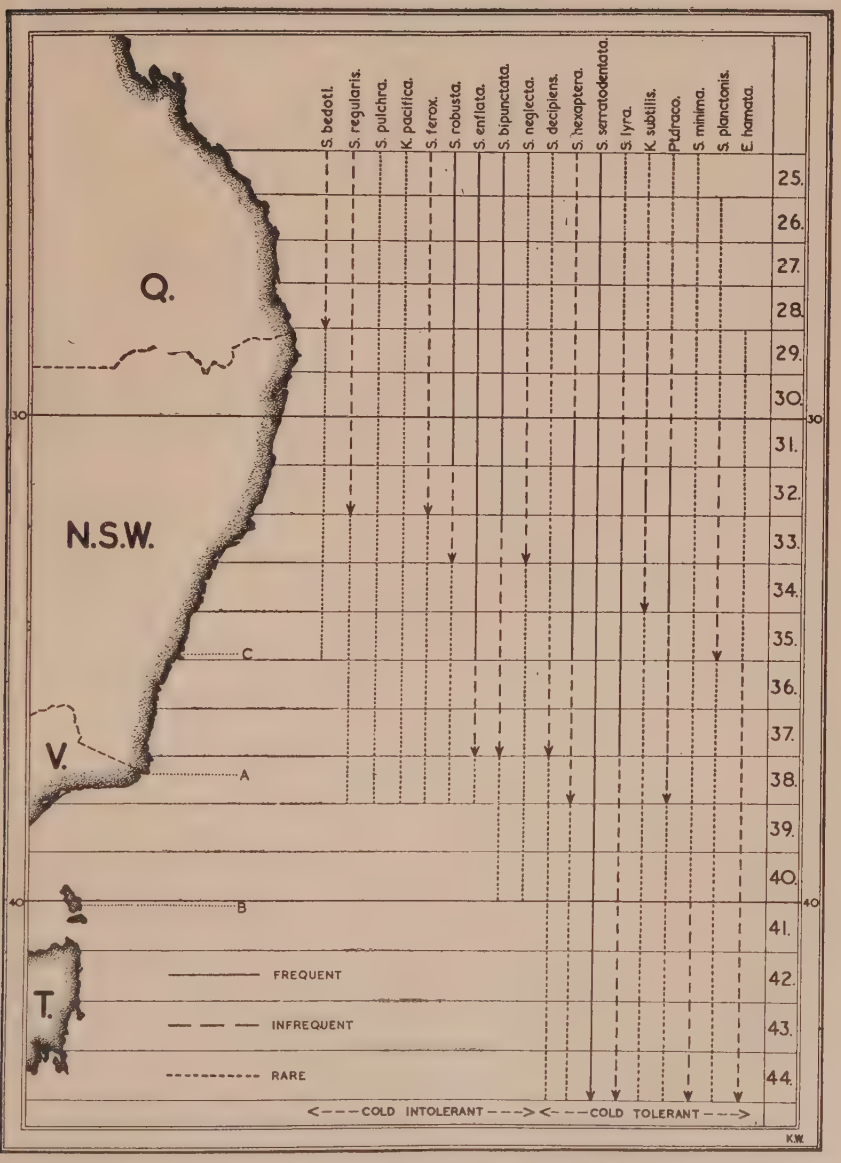

FIG. 4.—Distribution of Chaetognath species from north to south.

There remains a group of deep-water forms which do not show the marked fluctuations of the epiplanktonic types. Fig. 6 shows a slight decline towards tropical waters. But this is probably not an actual decline in occurrence but an effect of the relatively few samples taken from deeper waters north of 30°S. Also shown in Fig. 6 are the frequencies of occurrence of *S. serratodentata* and *S. lyra* whose subspecific behaviour has been shown in Figs. 2, 3, 5. It is evident that the composite picture of the subspecies of *serratodentata* and of *lyra* provide a graph very similar to that of the deep-water species. It is possible therefore that these latter species may also be divisible into geographic subspecies. *S. minima* appears to be larger in the colder waters but no other distinguishing morphological characters have been noted for the different population of these species.

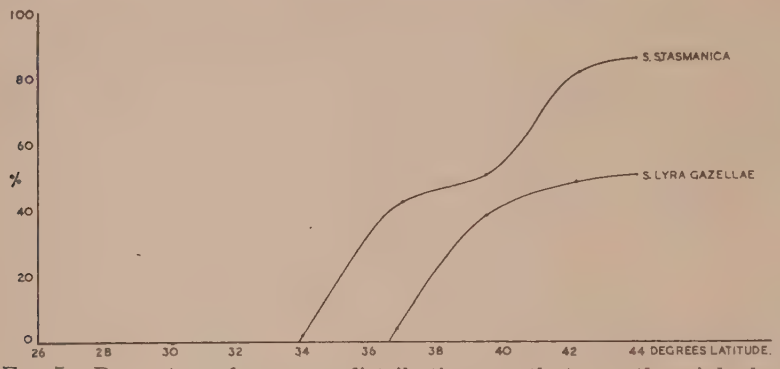

FIG. 5.—Percentage frequency distribution, north to south epiplanktonic species: Antarctic forms.

2. Victoria—South Australia

Thompson (1942) notes that there is a tendency for a reduced number of tunicate species to occur off the Victorian coast, and still fewer off South Australia. A similar reduction occurs in the Chaetognath fauna. Whereas 19 pelagic Chaetognaths occur off the New South Wales coast, only 7 have been taken in Victorian waters (*S. hexaptera, lyra, serratodentata, minima, decipiens, Pt. draco, E. hamata.*) and only 4 in South Australia (*S. hexaptera, neglecta, minima, Pt. draco*).

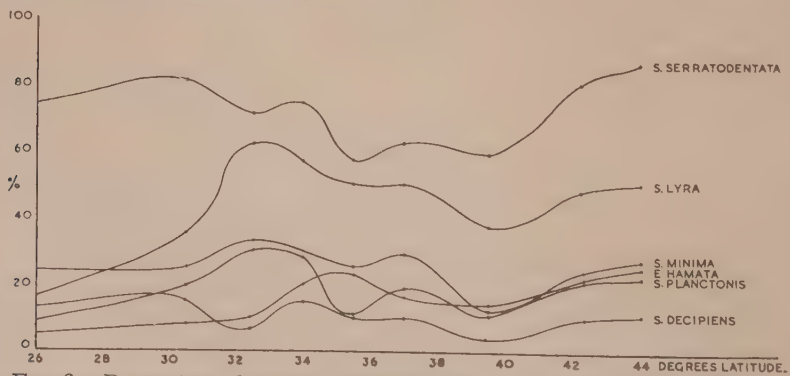

FIG. 6.—Percentage frequency distribution, north to south mesoplanktonic species.

3. Oceanic or Neritic

Apart from the genus *Spadella* the Chaetognatha are pelagic and as a rule oceanic. But certain species (*S. setosa* in European seas, *S. bombayensis* in Bombay harbour, *S. tumida* and *S. crassa* in Japanese waters) do occur in regions of reduced salinity. All the species from the *Warreen* plankton are generally regarded as oceanic, that is as occurring normally in the waters off the continental shelf. It was of interest then to ascertain to what degree the neritic inshore zone is penetrated. Table 1 presents the results as obtained from 113 stations beyond the continental shelf and 161 stations over the shelf.

TABLE 1.—OCCURRENCE IN OCEANIC AND NERITIC ZONES.

Species.	Oceanic Stations.		Neritic Stations.		Standard Error.	*t.*	Probability 100 x 2*r*
	Number.	Percentage.	Number.	Percentage.			
S. enflata ..	61	54·0	83	51·5	0·0613	0·40	6·7
S. hexaptera ..	66	58·4	36	22·4	0·0594	6·00	·01
S. lyra	89	78·7	50	31·0	0·0614	7·7	·01
S. s. pacifica ..	52	46·0	51	31·6	0·0595	2·4	1·64
S. s. atlantica ..	34	30·1	20	12·4	0·0515	3·4	·07
S. s. tasmanica ..	42	37·1	33	20·4	0·0549	3·0	·02
S. serratodentata ..	97	85·8	91	56·5	0·0569	5·1	·01
S. bipunctata ..	56	49·5	46	28·5	0·0594	3·5	·04
S. robusta ..	33	29·2	26	16·1	0·0506	2·6	·93
S. ferox	24	21·2	24	15·5	0·0461	1·4	23·01
S. bedoti ..	10	8·8	15	9·2	0·0396	0·1	89·0
S. neglecta ..	20	17·7	38	23·6	0·0501	1·2	23·01
S. regularis ..	24	21·2	22	13·6	0·0459	1·6	10·95
S. pulchra ..	2	1·7	5	3·1	0·0192	0·7	48·39
S. minima ..	52	46·0	54	33·5	0·0597	2·1	3·57
S. planctonis ..	35	30·9	22	13·6	0·0498	3·4	0·07
S. decipiens ..	40	35·4	5	3·4	0·0454	7·1	0·01
Pt. draco ..	71	62·8	49	30·4	0·0601	5·6	0·01
K. subtilis ..	47	41·6	19	11·7	0·0524	5·6	0·01
K. pacifica ..	12	10·6	7	4·3	0·0311	0·2	64·8
E. hamata ..	51	45·1	16	91·8	0·0527	6·7	0·01

Taking a 5 per cent. level of significance, all the species except *S. enflata, S. ferox, S. bedoti, S. neglecta, S. regularis, S. pulchra,* and *K. pacifica* show significant differences in their proportion of occurrence in neritic and oceanic waters. If a 1 per cent. level is taken, *S. minima* and *S. s. pacifica* also fail to show significant differences. For these two forms then the evidence is not quite conclusive. Nevertheless over 50 per cent. of the species can be regarded as oceanic. The presence of these oceanic forms in the neritic zone presumably results from the incursion of oceanic waters. It may be noted that of the 9 species which on the 1 per cent. level of significance do not show significant differences between their occurrence in neritic and offshore waters, 7 are tropical forms. Only one tropical form, *S. robusta,* has a significantly more frequent occurrence in oceanic waters.

Altogether 274 stations were sampled in the south-eastern Australia area. As a rule five* types of haul were made at each station but variations from one to eight occurred. From only 6 per cent. of the stations were Chaetognaths absent entirely. The frequency of occurrence of each species considering the entire south-eastern area is indicated by Table 2 below.

TABLE 2.—FREQUENCY OF OCCURRENCE: SOUTH-EASTERN AREA.

Species.	Number of Stations at which Recorded.	Percentage of Total Stations.
S. serratodentata	188	68·6
S. enflata	144	52·5
S. lyra	139	50·7
Pt. draco	110	39·7
S. minima	106	38·3
S. hexaptera	102	36·8
S. bipunctata	102	36·8
E. hamata	67	24·4
K. subtilis	66	24·0
S. robusta	59	21·5
S. neglecta	58	21·1
S. planctonis	57	20·8
S. ferox	48	17·5
S. regularis	46	16·8
S. decipiens	45	16·4
S. bedoti	25	9·1
K. pacifica	19	6·9
S. pulchra	7	2·5

As is shown in the table the species can be divided into four groups which may be termed dominant, sub-dominant, secondary, and rare groups.

4. Vertical Distribution

Vertical hauls at various depths were made. The average numbers (arithmetic mean) of Chaetognaths at the various depths were as follows:—

——	50–0 m.	100–50 m.	250–100 m.	500–250 m.
No. per haul ..	54	55	100	45
No. per 50-m. column	54	55	33	9

* N70 horizontal, oblique, vertical; N200 horizontal; N100 oblique.

The vertical distribution of the Chaetognath fauna as a whole as well as that of each species is shown in Fig. 7. Nine of the species were not taken below 100 metres. Of the remainder only *E. hamata* and *S. decipiens* appeared to be predominantly deep water forms. *S. minima* appears to be evenly distributed through the water column except for the uppermost 50 m.

The bulk of the Chaetognath population, as with the plankton in general, is concentrated in the upper 100 m. There appears to be a somewhat greater concentration between 25 m. and 50 m. than at the surface itself.

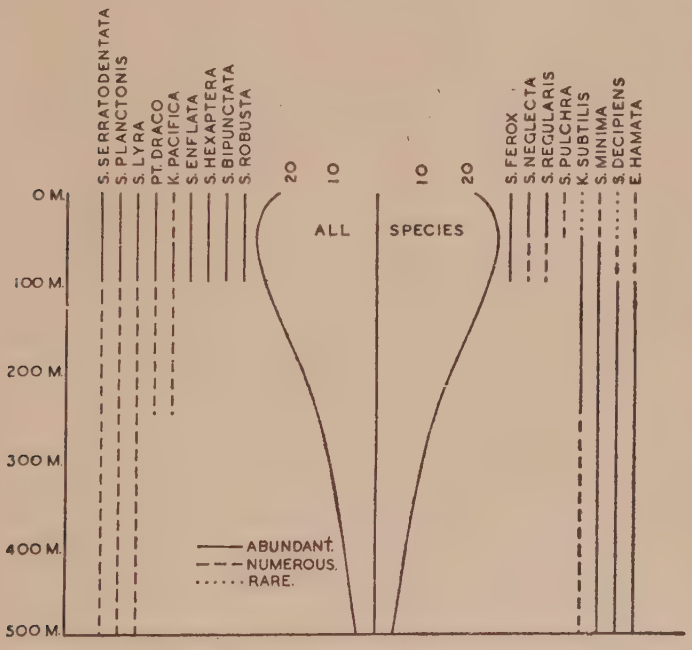

FIG. 7.—Distribution of species from 0 m. to 500 m.

5. Temperature Range

To some degree the vertical and geographical distribution is limited by the temperature tolerance of the animals. Fig. 8 below shows the temperature range of each species. The three sub-species of *serratodentata* are given separately. It will be seen that of those species which do not extend south of Bass Strait, only one has been taken in water of temperature lower than 13°C. The remaining species can be divided into two groups, those which occur in greatest concentration in warm waters but which are tolerant of cold conditions; and those which are centred mainly in cold waters and, except for *S. planctonis,* do not tolerate the warmest waters.

VI. THE PLACE OF CHAETOGNATHA IN THE PLANKTON

Russell (1934) found that the Chaetognatha in the Barrier Reef region comprised from 1-8 per cent. of the plankton. Hardy (1924) found that in the North Sea they comprised from 5-19 per cent.

In the Gulf of Maine Chaetognaths are the dominant animals in January and February (Bigelow, 1926). Thompson (1942) reports that by the method of visual estimation the Chaetognaths were the predominant animals in 1·2 per cent. of the *Warreen* collections. Though by no means always abundant, Chaetognaths were entirely absent from only 6 per cent. of the stations worked by the *Warreen*. They are therefore quite suitable as indicator organisms. The Chaetognaths take their place in the food cycle of the pelagic community as predators, competitors, and as prey. In their co-action with pelagic fish they occupy all three roles. In the North Sea Chaetognaths are second only to Copepods in importance as food of herring. Ehrenbaum records them in the food of mackerel. Other plankton forms such as Medusae also consume Chaetognaths.

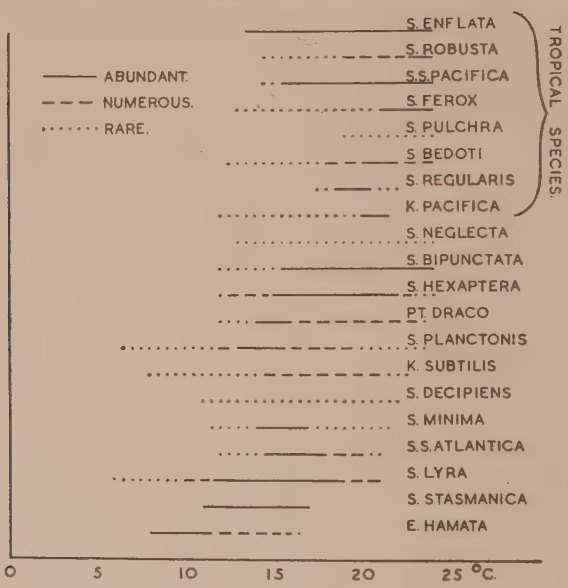

FIG. 8.—Temperature range, *Warreen* data.

The food of the Chaetognaths themselves consists mainly of Copepods, larval fish, and their own kind. Lebour (1922, 1923) reported the consumption of larval herring. Burfield (1927) found that diatoms and ciliates were taken. Both Chaetognaths and plankton-feeding fish eat large numbers of Copepods, and Bigelow (1926) estimated that the Chaetognaths might be more important than fish in reducing Copepod numbers.

Predatory animals which are themselves preyed upon make excellent intermediate hosts for various parasites. Chaetognaths are no exception (Lebour, 1917). Russell (1932*b*) found that 7 per cent. of *S. setosa* in the Plymouth area were infected with nematodes.

Lebour (1917) reported trematode parasites in Chaetognaths from the same region. Only a fraction of 1 per cent. of the *Warreen* Chaetognaths were found to be parasitized. The most frequent type was a larval trematode very similar to the species of *Derogenes* described by Lebour. A few *S. enflata* were taken with small yellow-coloured Cercariae in the body cavity. Only a very few nematodes were noted. On a specimen of *S. decipiens* was what appeared to be a parasitic Copepod attached in the region of the oviducal papilla.

Chaetognatha as Indicator Organisms

Bigelow (1926) was probably the first to suggest the possible use of Chaetognaths as indicator organisms. Later workers on the eastern American coast have confirmed his views. In this region the Chaetognaths can now be used as an index to the hydrological conditions; different species being characteristic of stable inshore, warm " Gulf " current and cold Arctic current conditions (see Fish, 1926; Cowles, 1930; Frost, Lindsay and Thompson, 1934; Fish and Johnson, 1937; Redfield and Beale, 1940; Clarke, Pierce and Bumpus, 1943).

In 1928 Meek showed that variation in hydrographic conditions off the Northumberland coast was correlated with the relative abundance of two Chaetognath species. In a series of papers Russell (1935*a*, 1935*b*, 1936*a*, 1936*b*, 1939) analysed the indicator correlations of Chaetognatha for the English Channel and the North Sea. Thus the presence of *S. setosa* in the North Sea indicates stable conditions. An influx of oceanic water either by way of the Straits of Dover or from the north is characterized by the occurrence of *S. elegans*.

In the English Channel besides the fluctuating occurrence of these two species, occasionally a third, *S. serratodentata*, indicates the admixture of " Biscay water." Fraser (1937, 1939) has examined the data for the northern North Sea and Scottish waters. Pierce and Orton (1939) have done similar work for the Irish Sea. Furnestin (1938) correlated the distribution of Sagittids in the North Sea with the salinity.

In the Indian Ocean John (1937) has shown that use of Chaetognaths may be made in interpreting water movements in the Madras area. Tokioka (1940*b*) has investigated their use in Japanese waters.

The examination of Australian material suggests that the only region along the Eastern Australian coast where use can be made of Chaetognaths as indicator forms is in the region between Flinders Is. in Bass Strait, and Jervis Bay (see Fig. 4), apart from the possibility of indication of the incursion of oceanic waters into the neritic zone. This area marks the limits of fluctuation in the southern-most penetration of warm-water species and, conversely, of the northern penetration of the cold-water forms of *S. lyra* and *S. serratodentata*. Thus when the *tasmanica* form of *serratodentata* is found north of 39°S. it may be assumed to indicate a northward penetration of colder waters from the Tasmanian area. The discovery of warm water forms such as *enflata, robusta*, or *ferox*, south of 38°S. would indicate an unusual southward penetration of warm water. Corresponding fluctuations in the boundaries of the occurrence of the *pacifica* and *atlantica* forms of *serratodentata* will occur.

VII. ZOOGEOGRAPHICAL RELATIONSHIP

There has been a considerable number of papers on the Indo-Pacific Chaetognaths. The literature is, however, very scattered and many authors seem to have worked in ignorance of the work of others. An author's list for subdivisions of this area is therefore given here, to be of use to future workers and to set out the authorities for the distribution table which follows.

(i) *The Australian Region*

Whitelegge (1889); Waite (1899); Johnston (1909); Ritter-Zahony (1909*b*, 1910*a*, 1911*a*); Johnston and Taylor (1919, 1921); Tokioka (1940*a*).

(ii) *New Zealand and Southern Pacific*

Kent (1870); Parker (1895); Fowler (1908); Ritter-Zahony (1909*b*); Benham (1912); Burfield (1930).

(iii) *California*

Michael (1911, 1913*a*, 1913*b*).

(iv) *China, Japan and Philippines*

Aida (1897); Moltschanoff (1907); Galzow (1909); Ritter-Zahony (1909*b*, 1911*a*); Michael (1919); Yamada (1933); Schodduyn and Leroy (1933); Tokioka (1938, 1939*a*, 1939*b*, 1939*c*, 1940*b*); Yosii and Tokioka (1939).

(v) *Malay Archipelago, East Indies, West Pacific Islands*

Beraneck (1895); Cleve (1901); Doncaster (1902); Fowler (1906); Ritter-Zahony (1909*b*, 1911*a*); Oye (1918).

(vi) *Northern Indian Ocean and Red Sea*

Doncaster (1902); Ritter-Zahony (1909*a*, 1909*b*); Bhatia (1924); Burfield and Harvey (1926); John (1933*a*, 1937); Lele and Gae (1936); Menon (1931); Subramaniam (1937, 1940).

(vii) *South Africa and Southern Indian Ocean*

Steinhaus (1896); Ritter-Zahony (1909*b*, 1911*a*); Gray (1923).

There is a great amount of synonymy amongst these papers but these have been corrected for the table of distribution. Any of the corrections which have not been made in the present paper have been dealt with by Fowler (1906), John (1933*a*), Tokioka (1939*c*, 1940*a*) or in the various papers of Ritter-Zahony.

The following doubtful species have not been included in the table:—*S. hispida* Burfield and Harvey (1926); *S. tenuis* Johnston and Taylor (1919); *S. tenuis* John (1933*a*); *S. levis* and *S. longicauda* Galzow (1909); *S. coreana* and *S. orientalis* Moltschanoff (1907); *S. pseudoserratodentata* Tokioka (1939*c*). Species of the benthic genus *Spadella* are not included.

TABLE 3.—ZOOGEOGRAPHICAL DISTRIBUTION.

—	Eastern Australia M.V. *Warreen*.	Eastern Australia Previous Records.	Western Australia.	New Zealand and South Pacific.	California.	China, Japan, and Philippines.	East Indies, Malaya, Pacific Islands.	North Indian Ocean and Red Sea.	South Africa and Southern Indian Ocean.	Atlantic.
S. hexaptera	X	X	..	X	X	X	X	X	X	X
S. lyra	X	X	..	X	X	X	X	X	X	X
S. enflata	X	X	X	..	X	X	X	X	X	X
S. bipunctata	X	X	X	..	X	X	X	X	X	X
S. serratodentata	X	X	X	.	X	X	X	X	X	X
S. neglecta	X	X	..	..	X	X	X	X	X	..
S. regularis	X	X	X	..	X	X	X	X	..	..
S. robusta	X	X	X	..	..	X	X	X	..	..
S. ferox	X	X	X	..	..	X	X	X	..	..
S. pulchra	X	X	X	..	X	X	X	X	..	..
S. bedoti	X	..	X	..	..	X	X	X	X	..
S. planctonis	X	X	..	X	X	X	X	X	X	X
S. decipiens	X	..	..	..	..	X	X	X	..	X
S. minima	X	X	X	..	..	X	X	X	X	X
S. macrocephala	..	..	..	..	..	X	X	X	..	X
S. elegans	..	..	..	..	..	X	..	..	..	X
S. setosa	..	..	..	..	..	..	..	..	..	X
S. parva	..	..	..	..	..	..	X	..	..	..
S. tumida	..	..	..	..	..	X	..	..	..	..
S. californica	..	..	..	..	X	..	..	..	..	..
S. crassa	..	..	..	..	..	X	..	..	..	..
S. helenae	..	..	..	..	..	..	..	..	..	X
S. friderici	..	..	..	..	..	..	..	..	..	X
S. bombayensis	..	..	..	..	..	..	..	X	..	..
Pt. draco	X	X	X	..	X	X	X	X	..	..
E. hamata	X	..	..	X	X	X	X	X	..	X
K. subtilis	X	X	X	..	X	X	X	X	..	X
K. pacifica	X	..	..	..	..	X	X	X	..	..
Z. cestoda	..	..	..	..	..	..	X	..	..	..
B. edentata	..	..	..	..	..	X	..	..	..	..
Number of species	18	14	11	4	13	23	21	20	9	15
No. common to *Warreen* material	..	14	11	4	12	18	18	18	9	10

The low numbers recorded from New Zealand and South Africa are due to the lack of any considerable number of samples from those areas. The whole of the western Pacific and the Indian Ocean appears to be fairly uniform as regards Chaetognath population. *S. macrocephala* is unlikely to have been obtained in Australian waters as it is confined to waters over 500 m. deep. Only one haul below this level was taken by the *Warreen*. *B. edentata* has been recorded from only one specimen taken in waters over 1,000 m. deep off Japan. *S. elegans* recorded from Japan is a cold water circum-polar form occurring only north of Japan. The other Japanese and Indian forms not recorded from Australia are brackish-water forms which could not be expected in oceanic hauls. Eight of the Indo-Pacific forms do not reach the Atlantic, while five Atlantic species have not been reported from the Indo-Pacific.

VIII. KEY TO THE GENERA AND SPECIES OF CHAETOGNATHA

The Australian genera and species are marked thus: (A).

The following doubtful or insufficiently described species of *Sagitta* are not included in the key to the species of that genus:— *S. hispida* Conant; *tenuis* Conant; *coreana* Moltschanoff; *euxina* Moltschanoff; *orientalis* Moltschanoff; *levis* Galzow; *longicauda* Galzow.

Key to the Genera of Chaetognatha

1. No tail septum; fossil . . . . . *Amiskwia* Walcott (1914).
   Tail septum present; extant . . . . . 2.

2. Two pairs of lateral fins; the posterior on trunk and tail . . 3.
   One pair of lateral fins, or two of which the posterior lies on the tail segment only . . . . . 4.

3. Ventral transverse musculature in trunk and tail . . . . *Zahonya* Oye (1918).
   Without ventral transverse musculature . . . . . (A) *Sagitta* Quoy and Gaimard (1827).

4. Two paired rows of teeth . . . . . 5.
   No teeth or one paired row . . . . . 7.

5. No collarette; lateral fins partly on trunk, partly on tail . . *Heterokrohnia* Ritter-Zahony (1911*a*).
   Marked collarette; lateral fins on tail only, or two pairs of which posterior lies on tail only . . . . . 6.

6. Collarette voluminous, foamy in appearance; one pair of lateral fins; without ventral transverse musculature; posterior teeth 8-18; oceanic . . . . . (A) *Pterosagitta* Costa (1869).
   Collarette large of usual structure; ventral transverse musculature; posterior teeth less than 5 . . . . . (A) *Spadella* Langerhans (1880).

7. Lateral fin extends to or in front of ventral ganglion; does not reach the seminal vesicle posteriorly . . . . . (A) *Eukrohnia* Ritter-Zahony (1909*b*).
   Lateral fin does not reach ventral ganglion, reaches seminal vesicles posteriorly . . . . . 8.

8. Transverse musculature in anterior trunk . . . . . *Bathyspadella* Tokioka (1939*b*).
   Without transverse musculature . . . . . 9.

9. One paired row of teeth; lateral fin mostly on tail . . . (A) *Krohnitta* Ritter-Zahony (1910*c*).
   No teeth; lateral fin mostly on trunk . . . . . *Krohnitella* Germain and Joubin (1912).

Key to the Species of *Sagitta*

1. Hooks with serrated margins . . . . . 2.
   Hooks without serrated margins . . . . . 3.
2. Point of hooks inwardly curved; mature over 12 m.m. . . .
   serratodentata (A).
   Point of hooks straight; mature at 7-9 mm. . . . . .
   pseudoserratodentata.
3. Lateral fins joined by rayless crosspieces . . . . . 4.
   Lateral fins separate . . . . . 5.
4. Anterior fins reach ventral ganglion . . . . . .
   maxima.
   Anterior fins do not reach ventral ganglion . . . . .
   lyra (A).
5. Anterior fins entirely rayless . . . . . .
   minima (A).
   Anterior fins not entirely rayless . . . . . 6.
6. Anterior fins do not come within half their own length of the ventral ganglion . . . . . 7.
   Anterior fins extend almost or quite to ventral ganglion . 11.
7. Tail more than 28 per cent. of body; head disproportionately large, much elongated anteriorly; numerous dark-brown teeth . . . . . *macrocephala.*
   Tail less than 28 per cent. of body; head proportionate, as wide as long . . . . . 8.
8. Fins completely rayed . . . . . 9.
   Fins with rayless anterior ends and inner zones; large flaccid species . . . . . 10.
9. Flaccid but slender; seminal vesicles near to posterior fin, distant from tail fin . . . . . .
   setosa.
   Rigid and slender; seminal vesicle distant from posterior fin, touching tail fin . . . . . .
   elegans.
10. Seminal vesicle touching tail fin; anterior teeth several, small and overlapping . . . . . .
    enflata (A).
    Seminal vesicle apart from both fins but nearer the posterior; anterior teeth few, large, dagger-shaped, spreading . . .
    hexaptera (A).
11. Posterior fin reaches vesicle . . . . . 12.
    Posterior fin does not reach vesicle . . . . . 21.
12. Seminal vesicle in contact with tail fin . . . . . 13.
    Seminal vesicle not in contact with tail fin . . . . 18.
13. Anterior of lateral fins rayless . . . . . .
    bedoti (A).
    Anterior of lateral fins completely rayed . . . . 14.

14. Collarette thickened along trunk and on to tail segment . . . *bombayensis.*

    Collarette, if extending behind front of anterior fin does so only as a thin lining . . . . . 15.

15. Seminal vesicle without a distinct head . . . . . *robusta* (A).

    Seminal vesicle with a distinct head . . . . . 16.

16. Anterior teeth more than 10 . . . . . *helenae.*

    Anterior teeth less than 10 . . . . . 17.

17. Collarette distinct; ovaries almost filling trunk cavity . . . *ferox* (A).

    Collarette indistinct; ovaries short and club-shaped . . . *friderici.*

18. Anterior of lateral fins rayless . . . . . *equatoria.*

    Anterior of lateral fins completely rayed . . . . 19.

19. Collarette bulky, extends to anterior edge of head; posterior teeth less than 7 . . . . . *regularis* (A).

    Collarette not extending to anterior edge of head; posterior teeth more than 10 . . . . . 20.

20. Collarette extensive; seminal vesicles with slight anterior head . . . . . *crassa.*

    Collarette not extensive; seminal vesicles ovoid, without a head . . . . . *neglecta* (A).

21. Seminal vesicles in contact with tail fin . . . . . 22.

    Seminal vesicles not in contact with tail fin . . . . 25.

22. Seminal vesicle a low projection approaching close to posterior fin . . . . . *pulchra* (A).

    Seminal vesicles prominent, apart widely from posterior fin . . . . . 23.

23. Fins with anterior apices rayless; no thickening of collarette . . . . *decipiens* (A).

    Fins completely rayed; collarette reaches seminal vesicles, thickening immediately in front of vesicle . . . 24.

24. Collarette massive along body . . . . . *californica.*

    Collarette inconspicuous along body . . . . . *bipunctata* (A).

25. Seminal vesicle approaches tail fin; posterior teeth more than 8 *planctonis* (A).

    Seminal vesicle half-way between fins; posterior teeth less than 8 . . . . . *parva.*

Key to the Species of *Spadella*

1. Ventral transverse musculature over anterior trunk region . . *schizoptera.*

   Ventral transverse musculature over the whole trunk region . 2.

2. Ventral transverse musculature in tail as well as trunk; one row of teeth . . . . . *moretonensis* (A).

   Ventral transverse musculature not in tail; teeth in two rows *cephaloptera.*

Key to the Species of *Krohnitta*

Body transparent; mature ovary very short; a slender species . . *subtilis* (A).

Body opaque; mature ovary elongate, reaching to anterior end of lateral fin; relatively broad species . . . . . *pacifica* (A).

The remaining genera are monospecific, namely:—

Amiskwia sagittiformis.

Zahonya cestoda.

Heterokrohnia mirabilis.

Pterosagitta draco.

Krohnitella bourei.

Eukrohnia hamata.

IX. ACKNOWLEDGMENTS

The hauls for the year June 1938 to June 1939 were studied while the author was working under a C.S.I.R. Research Grant in the Biology Department of the University of Western Australia. Mr. L. Glauert, Curator of the Western Australian Museum, kindly made available specimens identified by Ritter-Zahony from the Hamburg Expedition material. Professor T. Harvey Johnston readily made available co-types of his *S. australis.* The Australian Museum, and the Zoology Department of the University of Sydney, gave access respectively to the holotype and sections of *S. australis.* Mr. K. Wilson prepared the figures other than Fig. 1, under the supervision of Mr. A. Proctor.

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151. The Control of St. John's Wort (Hypericum perforatum L. var. angustifolium D.C.) by Competing Pasture Plants
152. Soil Survey of Part of County Moira, Victoria, including the Parishes of Boosey, Cobram, Katamatite, Naringaningalook, Katunga, Yarroweyah, and Strathmerton
153. Pelagic Tunicates in the Plankton of South-eastern Australian Waters, and Their Place in Oceanographic Studies
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165. Potato Virus X.: Mixtures of Strains and the Leaf Area and Yield of Infected Potatoes
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168. A Survey, Census, and Statistical Study of the Horticultural Plantings on the Murrumbidgee Irrigation Areas, New South Wales
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170. Pea Mosaic on Lupinus varius L. and other species in Western Australia
171. Experiments with Insecticides against the Red-legged Earth Mite (Halotydeus destructor (Tucker)).
172. Zebu-cross cattle in Northern Australia. An Ecological Experiment
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